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The Characteristics of Crackers Made from Formulation of Wheat and Modified Water Yam Flour

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ABSTRACT

The previous study showed that combination of wheat flour (70%) and modified water yam flour (30%) produced crackers which had the best characteristics. In this research, the effect of formulation of wheat and three kind of modified water yam flour on Resistant Starch (RS) content and Glycaemic index of the crackers were studied. Modified water yam flour was made from purple, white, and yellow ones which had been treated by three cycles autoclaving-cooling process. The native water yam flour, without treatment with autoclaving, were used as comparison. The result showed that sample crackers had higher resistant starch (1.67 -3.65%) and dietary fiber (16.65 -18.41%) content, compared to standard crackers from wheat flour. Furthermore, the crackers from modified yam flour with white water had the lowest GI (34.13) comparing with other crackers. So it could be developed as functional food for preventing diabetes mellitus or other digestive tract disrupter.

Keywords*: crackers; glycemic index; modified water yam; resistant starch*

INTRODUCTION

The digestive problem is related to the changing in eating habit. The tendency to consume foods derived from animal-based foods and consuming less plant-based foods that are rich in dietary fiber caused digestive disrupture, such as diabetes, obesity, constipation, hypercholesterolemia and colon cancer. People with digestive problems need to control their food with functional foods that are useful to prevent the prevalence of these diseases, particularly foods rich in dietary fibers and starch resistant (Gunawan, A., Tandra, 1998).

Foods rich in dietary fibre, and starch resistant are now widely studied as functional foods, especially for diabetics patients and sufferers of other digestive diseases. WHO estimates that the number of diabetics patients worldwide will reach 135 million in 1995 and will increase to 300 million in year 2025. Currently it is estimated that diabetics in Indonesia reach 1.5-2.3% of the population older than 15 years. The prevalence of diabetes mellitus in Indonesia from year to year is always increasing and is estimated to reach 5 million in 2020 (Gunawan, A., Tandra, 1998).

The society trend towards functional food recently increased, especially in the developing country. Many people were potentially suffered chronical disease, such as diabetes mellitus. According to (BPOM, 2005), functional foods are foodstuffs or food components have health benefits besides its main nutrition benefits. Functional food is food in its nature or has been through certain processes that contain one or more compound , which based on scientific studies relating to certain physiological functions that are beneficial to human health, for example foods rich in dietary fiber and resistant starch.

Starch resistant is product of starch or starch degradation that cannot be digested by a healthy human intestine (Asp, N-G, Bjorck, 1992). Heating and cooling the starch-based product would change the starch structure from insoluble to retrograded starch. Gelatinization and retro gradation process, which were often occurred in starchy food processing, can affect starch digestibility in human small intestine.

Water yam (*Dioscorea alata* L. sin., *D. atropurpurea* Roxb., *D. purpurea* Roxb., *D. sativa* Del.) had irregular form tuber. The tuber had white, yellow or light purple color. Water yam could be eaten by steaming, frying or mixing with other flour in making cake (Mudita, 2012). Previous research has shown that autoclaving-cooling procedure in three stages the resistant starch content increased and the digestibility reduced (*in vitro*) of water yam. Modified red, yellow, also white of water yam flour was very strong against starch content

(7.55% db, 7.14% db, and 9.04% db , respectively). To prepare the modified flour, tubers stuffed with hot yam in autoclave at 121^{o}C for 15 minutes and refrigerated at 4^{o}C for 24 hours (these process were repeated for 3 times) refrigerator, milling and sieving before drying (Rosida et al., 2018). Furthermore, these flour were used as subtitution agent of wheat flour in making crackers. Until 30% substitution level of modified flour, the crackers was still preffered by the panels in term of taste, color, and texture (Rosida et al., 2015).

Cooking and cooling starch based products were known to cause starch retro gradation which increase resistant starch content. Resistant starch had characteristic and function like dietary fiber, such as having low calorie, decreasing glycemic Index (GI), lowering blood cholesterol level and controlling colon cancer risk (Liu, 2005).

Glycemic Index (GI) is a classification indicator; food-containing carbohydrates based on their blood glucose-raising capacity, linked to the food's glucose response, whereas the glucose response is related to the digestibility of the food. Foods with low GI are generally caused by low digestibility due to the presence of dietary fiber and starch soluble in food. Foods with low GI are needed to prevent diabetes in humans, especially for diabetics patients to reduced blood glucose levels.

Glycemic Index (GI) also defined as the ratio of foods containing total carbohydrates between the glucose response curve region of 50 grams of sugar and the glucose response curve area after consuming 50 grams of glucose, on different days and on the same person. Both tests were carried out in the morning after fasting one night and the determination of sugar levels was carried out for 2 hours. In this case glucose or white bread is used as a standard (with a value of 100) and a percentage of the GI value of the food being tested (Truswell, 1992).

This study evaluated the influence of consumption of crackers made from modified water yam flour and wheat flour formulation to postprandial response and glycemic index (GI) of crackers using experimental rats.

Crackers is a type of biscuits commonly used as dietetic food and snacks between meals. Besides being used as a snack food, crackers are widely used as breakfast foods, like bread, which is eaten with milk or mayonnaise. This product has good prospects for developing produk as a dietetic food because of its low sugar and fat content (Manley, 2000).

This study aimed to characterize crackers made of modified water yam flour substitution of wheat flour and to evaluate their glycemic response and glycemic index using eexperimental rats. This analysis is expected to yield results further developed as functional food for humans for diabetics patients and for healthy humans to prevent diabetes and other digestive problems

METHODS

Food samples

Three kinds of Tuber (yellow, purple, white) Autoclaved-cooled water yam (Dioscorea alata) (up to 3 cycles) before peeling, slicing, drying and milling to make modified water yam flour. Autoclaving processed used autoclave at 121 ^{o}C (15 minutes) and at 4 ^{o}C (24 hours) cooling process used refrigerator. Water yam flour without autoclaved-cooled treatment were used as comparison.

Water yam flour was used to substitute 40% of wheat flour to make crackers and abbreviated as PW (purple water), MPF (modified purple flour), WW (white water), MWF (modified purple flour), YW (yellow water), MYF (modified yellow flour). Standard wheat crackers were made from 100% of wheat flour, fat, salt, sugar, dry yeast and lamination was made from wheat flour and fat. Standard wheat crackers was used as control.

Chemical analysis

The control and sample crackers moisture, ash, fat and protein were analyzed by AOAC method (AOAC, 2016), and dietary fiber and resistant starch content (Englyst, H.N., Cummings, 1987).

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Experimental animals

Twenty four male Wistar rats (100-150g body weights) they were divided into 8 groups (3 rats per group) and kept individually in controlled metabolic cages, between 20-25 ^{o}C, 12 hours light and dark cycle. The animals were re-weighed and fasted for 12 hours after 7 days of adaptation (overnight fasting) and tested at zero time for blood glucose before administration in the amount of test food (standard and sample crackers) containing 0.2 g carbohydrates. Blood glucose was determined after 30, 60, 90 and 120 minutes. The same method was used with the 0.20 standard glucose control group dissolved in distilled water.

Glucose in the blood was measured using methods GOD-PAP (McGowan et al., 1983). Blood samples (*plexus retroorbitalis*) were taken from eyes. For each diet, the Glycemic Index (GI) calculation of the Average Region Within a two-hour blood glucose curve (IAUC) for diet, and compared to the standard GIC glucose solution IAUC (Jenkins, D.J.A, Wolever, T.M.S., Taylor, 1981), using the équation below:

$$GI = \frac{\text{Incremental Area Under 2h blood glucose Curve for food}}{\text{Incremental Area Under 2h blood glucose Curve for glucose or white bread}} \times 100$$

RESULTS AND DISCUSSION

Table 1, showed that there are differences in chemical composition of the six kinds of the crackers, which were made from 40% substitution of wheat flour. Made of water yam flour modified (purple, white, yellow), crackers were getting more dietary fiber (16.65-18.61%) and resistant starch (1.67-3.65%) than those of native ones (without autoclaving-cooling treatment).

Table 1. Chemical composition of crackers made from 60% of wheat flour and 40% of water yam flour

Crackers	Components						
	moisture	ash	fat	protein	carbohydrate	Dietary fiber	Resistant starch
Wheat+PW*	2.11	2.05	15.37	9.59	70.86	13.24	1.52
Wheat +WW*	2.13	1.99	15.63	9.18	71.05	13.58	1.67
Wheat +YW*	1.98	1.96	14.79	9.66	71.59	12.33	1.17
Wheat+MPF*	3.34	1.00	14.29	11.36	68.99	17.57	3.33
Wheat +MWF*	3.15	2.39	13.68	11.25	69.51	18.61	4.09
Wheat +YWF*	3.24	2.20	13.74	10.88	69.93	16.65	3.65

*PW = puple water; MPF= modified purple water; WW = white water; MWF= modified white water; YW = yellow water; MYF = modified yellow water

The data of chemical composition were used to calculate the amount of each crackers to make an equivalent amount of carbohydrate in standard amount (0.2) of glucose (Jenkins, D.J.A, Wolever, T.M.S., Taylor, 1981).

The results show that blood glucose responses increased to the highest values of 135.48 mmol/L for glucose as standard and 121.07 mmol/L for wheat crackers 90 min after the animals are started feeding meals (Fig 1).

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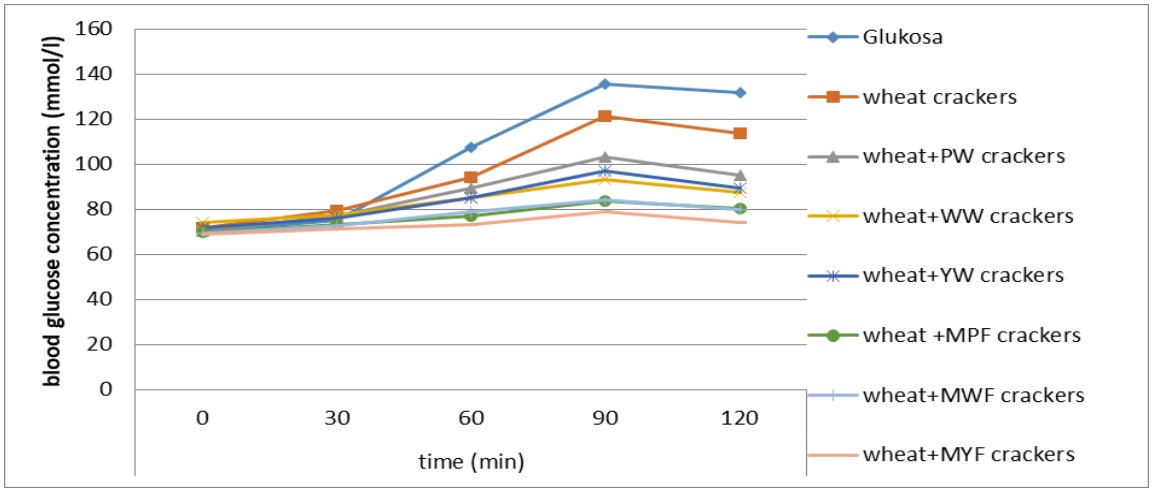

Fig 1. Blood glucose response and Glycemic Indeks of crackers

Table 2 showed the mean values of IAUC for crackers substituted with native and adjusted water yam flour below regular crackers. However, crackers substituted by modified purple, white and yellow water yam flour were developed a relative lower IAUC values (176.43, 140.96, and 172.59 mmol.min/L, respectively)

Table 2. Blood glucose response, IAUC and Glycemic Index of Crackers diet fed to healthy rats

Diet	Blood Glucose Response (mmol/L)					IAUC	GI
	Time (min)						
	0	30	60	90	120		
Glucosa	70.28	75.01	107.23	135.48	131.86	413.01	100
Standard crackers	71.75	79.25	94.24	121.07	113.52	300.58	72.77
Wheat+PW*	70.28	76.97	89.29	103.34	95.18	213.60	51.72
Wheat+WW*	69.61	72.96	76.84	83.53	80.32	178.13	43.13
Wheat +YW*	74.16	77.38	85.28	93.17	87.68	194.07	46.99
Wheat +MPF*	69.35	72.69	78.85	84.34	80.05	176.43	42.72
Wheat +MWF*	71.89	75.90	84.88	97.06	89.42	140.46	34.13
Wheat +MYF*	69.08	71.49	73.36	78.85	73.90	172.59	41.66

These values of IAUCs would yield corresponding respective low GI values, such as 42.72, 34.13, and 41.66 for crackers subtituted by modified purple, white and yellow water yam flour fed to rats. Therefore, partial substitution of modified water yam flour might change the glycemic response of the standard crackers. It is caused those crackers had high dietary fiber and resistant starch (Table 1).

The results showed crackers made with 40% of modified water yam flour produced the lowest postprandial blood glucose at 90 min in comparison to standard wheat crackers and those made with native water yam flour substitutions, GI was lower after ingestion. Therefore, RS will protect against hyperglycemia by reducing post-prandial glycemic response (Lin, M-H. A., Shyr, C-R., Lin, 2012).

Differences in blood glucose responses in human subjects and animals for different foods and within the same group of foods, different factors, such as chemical composition or food components, components and the quality of carbohydrates, dietary fibers, food processing methods and the presence of any substances that act as enzyme digestion inhibitors. (Björck et al., 1994). Digestion rates and carbohydrate intake in a mixed meal may vary according to the composition of the meal, so far, affecting the GI value may be toward

the beneficial in reducing the risk of some nutritional disrupter such as diabetes (Thannoun, A.M., Al-Kubat, 2010).

Furthermore, the meals which contain high dietary fiber and resistant starch had given low GI value comparing with other meals. The high fiber meals were digested and absorbed lower than low fiber ones, so they resulted ini low blood glucose responses in rats (Björck et al., 1994).

CONCLUSION

In conclusion, 40% substitution of modified water yam flour to wheat flour produced cracers which had high Resistant Starch content (1.17-4.09%) and dietary fiber content (12.33-18.61%). The consumption of these crackers might change the blood glucose response and its GI. Glycemic index of sample crackers are lower (34.13-51.72%) than GI of standard crackers (72,77), especially crackers made of modified white water yam flour substitution (34.13) due to its high dietary fiber and resistant starch.

The results showed that substitution of 30% of modified water yam flour to wheat flour resulted in lowering the GI of the crackers, especially from that of modified white water yam flour, from 72.78 to 34.13.

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